ANALYSIS OF SEISMIC DATA FROM THE AFRICAN CONTINENT

H. James Dorman PI

Lamont-Doherty Geological Observatory
Columbia University
Palisades, New York

Grant No. AF49(638)-1723

Project Task No. 8652

Final Report

Period Covered: 1 April 1966 - 31 March 1969

15 April 1970

Prepared for

AIR FORCE OFFICE OF SCIENTIFIC RESEARCH
OFFICE OF AEROSPACE RESEARCH
UNITED STATES AIR FORCE
WASHINGTON, D.C.

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PROJECT VELA-UNIFORM

ARPA ORDER NO. 292 Amendment 32

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INTRODUCTION

Early in 1965, the Lamont-Doherty Geological Observatory established a high-sensitivity short-period seismic array consisting of three elements, a central station at Abeche, and two satellite stations 15 km to the south and west of Abeche. In addition, a three-component set of low-gain, long-period seismographs was set up at Abeche. The short-period instruments operated at a gain of 370,000 while the long-period instruments operated at a gain of 1,500. Data were recorded on photographic records and magnetic tape. In addition, a long-period station was established at Lamto, Ivory Coast, early in 1966. A complete description of this instrumentation is available in the Final Report of grant AFOSR 678-64.

Under the subject contract, work was started in 1967 on establishing a three-component high-gain wide-band long-period system at Abeche. This effort was successful and about four months of very high quality output at a gain of about 100,000 at 30 sec were recorded before the termination of the Abeche station in June, 1968. Equipment was removed from Lamto in February, 1968. The Abeche installations, in an area with less than 1 millimicron of microseismic noise at 1 cps, provided high-quality recordings for many studies directly applicable to the VELA-UNIFORM program.

Maintenance and improvement of instrumentation in the Fiji Islands was accomplished in 1966 at the request of the project monitor. Throughout the program, paper seismograms from Abeche

and Lamto and magnetic tape, when available, were sent to the project monitor for seismic events of particular interest. Dr. Pomeroy also submitted a report dated November 8, 1967, summarizing items of interest to Project VELA-UNIFORM which were reported at the Zurich meeting of IUGG.

SCIENTIFIC RESULTS

The following research projects have been carried out with the support of contract AF49(638)1723:

1. The detection capability of Abeche for about 400 events reported by the USCGS for February and March, 1968, was compared with the detection capability of LASA for the same events. LASA reported 72% of these events and 70% were recorded at Abeche. The minimum magnitude at which 90% of these events are detected in the observations of the two stations was obtained as a function of distance. From this, LASA and Abeche were found to have roughly equal capability. The remarkable capability of Abeche can be ascribed to the great band-width and high magnification at this favorable site. Noise levels here are much lower than at most seismograph stations. Reception of short-period PKP waves from distances greater than 130° is also good at Abeche.

2. The M_b/M_s ratio was determined for Abeche for 112 USCGS-reported events for the same period. This showed that body waves from events in the Greece-Turkey region systematically arrive at Abeche with amplitudes that are higher than indicated by the USCGS

magnitudes. This makes the M_b-M_s ratio of these events higher than that of events of other azimuths. The higher ratio is probably due to efficient body wave propagation rather than fault plane orientation since the surface wave arrivals from the Greece-Turkey region have about the same amplitude as expected from the USCGS magnitude. Detailed discussions of items 1 and 2 are contained in quarterly progress reports on this contract.

3. Liebermann and Pomeroy (1969) studied the surface-wave magnitude (M_s) used as the measure of the relative excitation of long-period waves by underground explosions, presumed underground explosions, and earthquakes in five distinct geographical and tectonic regions of the world: the western United States; the Aleutian-Kamchatka area; southern Algeria; central Asia; and Novaya Zemlya. The M_s va. m_b data indicate that the underground explosions generated smaller surface waves than earthquakes from the same region of comparable body-wave magnitudes (m_b). For the events (m_b 5) and regions studied, the most significant result is that it is impossible to separate the earthquake and explosion populations on the basis of their surface-wave magnitudes if the events are analyzed on a regional basis. Theoretical considerations of the dimensions of the seismic source in space and time lead to M_s va. m_b relationships which account for the general trend of the observational data.

4. Gumper and Pomeroy (1970) determined phase and group velocities of seismic surface waves for several paths across the

African continent. These results indicate significant differences between the structure of the Canadian shield and that of Africa.

5. A paper by Lahr and Pomeroy (in press) dealt with the foreshock-aftershock sequence of the March 20, 1966 earthquake in Uganda. This paper emphasized the distribution of the aftershocks in time and in magnitude. The time decay of the number of shocks, n, can be expressed $n=A/t^p$ where t is time and p is determined to be 0.71. This decay of activity, typical of an aftershock sequence, contrasts with the occurrence of swarms which characterize mid-ocean ridge sequences. The magnitude of the foreshocks and aftershocks are distributed according to the expression $\log n=a-bm$. The b value of the foreshocks and the aftershocks is about 1.0, and is in general agreement with b values derived for other sequences throughout the world.

6. Funds from this contract were provided with permission of the contract monitor, for expenses of Prof. Kazim Ergin to continue his research on seismic core phases. While at Lamont in 1966-67, Prof. Ergin was employed as an AFOSR visiting scientist. After leaving in February, 1967, he continued his work with assistance from the present contract. Seismogram copies were purchased for Prof. Ergin with these funds. In his latest paper based on this data, Ergin (1969) describes observed regional time anomalies as large as 8 sec of the phases SKS, PKIKP and P (diffracted). He concludes that these effects are mainly due to horizontal variations in body wave velocity in the earth's core and near the core-

mantle boundary. Such anomalies are a function of source and receiver positions and are large enough to figure in the identification and analysis of phases in a large collection of fixed-array data as from LASA.

7. Support was derived from this contract for development of high-gain instrumentation at Abeche and Ogdensburg. Because of the excellent vault and very favorable seismic background noise conditions at Abeche, the opportunity to work on advanced instrumentation at that locality made a significant contribution to the progress of those efforts. Contributions by Pomeroy, Hade, Savino, and Chander (1969) and by Molnar, Savino, Sykes, Liebermann, Hade, and Pomeroy (1969) grew out of this work.

8. Data from Lamto and Abeche have been important in derivation of focal mechanism solutions (Sykes 1968, 1969), especially because of the relative scarcity of other seismograph stations on the African continent.

Publications Resulting from Work Done on AFOSR Grant AF49(638)1723

Banghar, A.R. and L.R. Sykes, Focal mechanisms of earthquakes in the Indian Ocean and adjacent regions, J. Geophys. Res., 74, 632. 1969.

Ergin, Kazim, Seismic core phases and the later inhomogeneities in the earth's core, J. Geophys. Res.

Gumper, F., and P.W. Pomeroy, Seismic wave velocities and earth structure in the African continent, Bull. Seism. Soc. Am., April, 1970.

Liebermann, R.C. and P.W. Pomeroy, Relative excitation of surface waves by earthquakes and underground explosions, J. Geophys. Res., 74, 1575, 1969.

Liebermann, R.C. and P.W. Pomeroy, Excitation of surface waves by events in Southern Algeria, Science, 156, 1098, May 26, 1967.

Molnar, P., J. Savino, L.R. Sykes, R.C. Liebermann, G. Hade, and P.W. Pomeroy, Small earthquakes and explosions in western North America recorded by new high-gain, long-period seismographs, Nature, 224, 1268, 1969.

Pomeroy, P.W., G. Hade, J. Savino, R. Chander, Preliminary results from high-gain, wide-band, long-period electromagnetic seismograph system, J. Geophys. Res., 74, 3295, 1969.

Sykes, L.R., Seismological evidence for transform faults, sea floor spreading and continental drift, from The History of the Earth's Crust, edited by R.A. Phinney, Princeton University Press, Princeton, N.J., 1968.

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13. ABSTRACT

A three-component high-gain, wide-band, long-period seismograph system was operated in Africa at Abeche, Chad. The installations provided high-quality recordings for many studies directly applicable to the VELA-UNIFORM program. This report gives a concise account of the work done at Abeche and the published results of that work.

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